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## *Phagocata iwamai*, a New Freshwater Planarian, from Hokkaido<sup>1)</sup>

*With 5 Text-figures*

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(Communicated by T. UCHIDA)*

About ten years ago, A. Ichikawa collected in the stream running through the campus of the University, Sapporo City, a few specimens of freshwater planarians, which seem to be a new species of the genus *Phagocata* (cf. Ichikawa 1954: the abstract of the lecture delivered before the 24th Annual Meeting of the Zoological Society of Japan held in Kyoto, on Nov. 1st-2nd, 1953). Since then the species has occasionally been collected from this locality and in the suburbs of the city, but no fully mature worms were found.

In the summer of 1957, however, numerous mature worms of this species were collected by M. Kawakatsu from a brooklet, in Wakkanai City, in North Hokkaido. Subsequently we also received from Mr. T. Yamada of Nayoro High School, several preserved specimens, a sketch of the worm in life and a set of the diagrams of the copulatory apparatus of this species, for identification. He informed us personally that he had found this species in abundance in a spring-fed stream in the vicinity of his house, Nayoro City, in North Hokkaido, and that its sexual organ matured in the early spring. In May, 1961, we visited Yamada's locality under his guidance, and succeeded in obtaining very numerous mature worms of this species.

We re-examined a sufficient number of the worms of our material and came to the conclusion that the copulatory apparatus of this species differs in almost every detail from that of the other species of the genus *Phagocata* which were described hitherto in Japan and in other countries. In view of our findings we have established this form as a new species.

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1) Contribution No. 517 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.

Good fixation and staining were obtained with the standard methods we are accustomed to employing (2% HCl, Bouin's fluid and Delafield's haematoxylin with eosin). Some of them were stained by borax-carmin and by the fluid of a Chinese ink-stick as whole mounts (for details, see Ichikawa and Kawakatsu, 1961, pp. 14-18).

Order TRICLADIDA  
 Suborder PALUDICOLA OR PROBURSALIA  
 Family PLANARIIDAE  
 Genus *PHAGOCATA* Leidy, 1847  
*Phagocata iwamai*,<sup>2)</sup> new species

*Description.* *Phagocata iwamai* is a slender, rather small pigmented species. Figure 1 (A and B) shows the photographs of this species from life, of specimens from Nayoro City.

Mature living worms have a maximum length of 12 mm and a typical shape of the genus *Phagocata*, with truncate head, without conspicuous tentacles. The

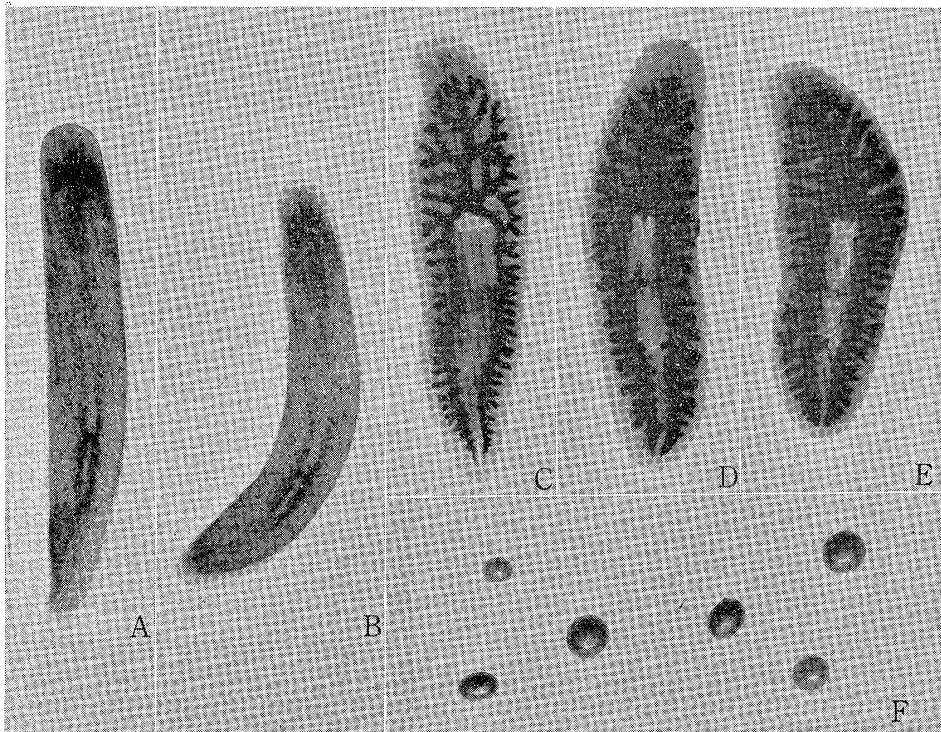


Fig. 1. *Phagocata iwamai*, new species. All from Nayoro City. A and B: photographs of living specimens. Actual length, 10-12 mm. C, D and E: intestine variants from whole mounts. F: living egg capsules (cocoon). Jelly-like substance surrounding the egg capsule is removed. Actual sizes, 0.8-1.5 mm×0.7-1.2 mm.

2) We have named the species in honor of Mr. Haruo Iwama, who made an attempt to re-classify freshwater planarians of North Japan for his graduation thesis at Hokkaido University (not published).

body then gradually widens. From the levels of the mouth and the genital pore it narrows somewhat to the rounded posterior extremity.

In color the worms are dark grey, or greyish brown, or medium black, without showing definite spots. The situations of the pharynx and the copulatory apparatus may be marked by slightly lighter pigmentations. The head region and the body margin are almost colorless or light colored. In the large worms, a dark, mid-dorsal, longitudinal strip is invariably present. Each of the two eyes is enclosed in a small reniform clear space. They are relatively far behind the anterior margin; their distance from each other amounts to about one-third to one-fourth of the head width at the eye level. The auricular sense organ, a pair of light colored strips, occupy the usual position. In mature worms, the pharynx is situated behind the middle of the body and measures in length almost one-sixth the length of the body. The genital pore opens near the midway point between the mouth and the posterior end.

Concerning the body forms, the contours of the head region and the color tints of our material, there are no noticeable differences between Sapporo and Nayoro and Wakkai specimens. On the other hand, the general appearance of this species in life shows a close resemblance to other Japanese species of the same genus, particularly to *Phagocata kawakatsui* Okugawa (1956).

The general histology of the present material appeared to offer nothing of particular interest. The caved-in epithelium, which is found in the center of the ventral anterior tip of the body in many *Phagocata* species, is also seen in this species; the histology of this organ bears a striking likeness to that of *Phagocata albata* Ichikawa et Kawakatsu (1962).

The pharynx of this species is structurally typical of the family Planariidae: the muscle zone consists of two layers, the thick circular fibres with the epithelium of the pharynx lumen and the thinner longitudinal fibres. The anterior intestinal trunk bears 5 to 8 lateral branches; each posterior trunk bears a fairly large number, about 20 or more pairs, of lateral branches. Figure 1 (C, D and E) shows the variations of intestine from whole mounts of three mature specimens.

The arrangement of the parts of the reproductive system was seen translucently from the whole mount (Fig. 2). The numerous testes extend in lateral regions from the level of the third or the fourth intestinal diverticulum almost to the posterior

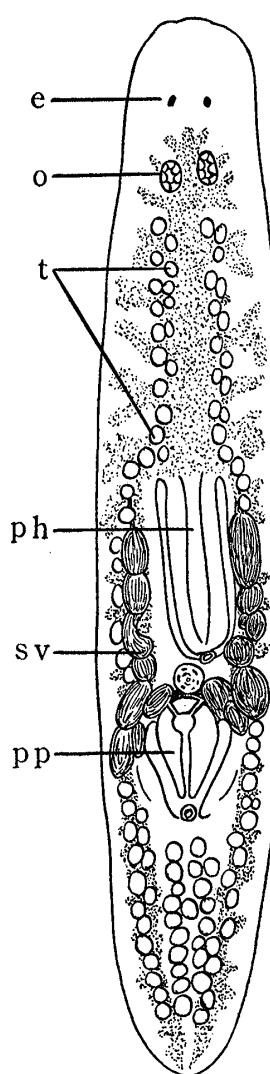


Fig. 2. General view of a mature specimen from whole mount, borax-carmine stain. e: eye, o: ovary, ph: pharynx, pp: penis papilla, sv: spermiducal vesicle, t: testis.

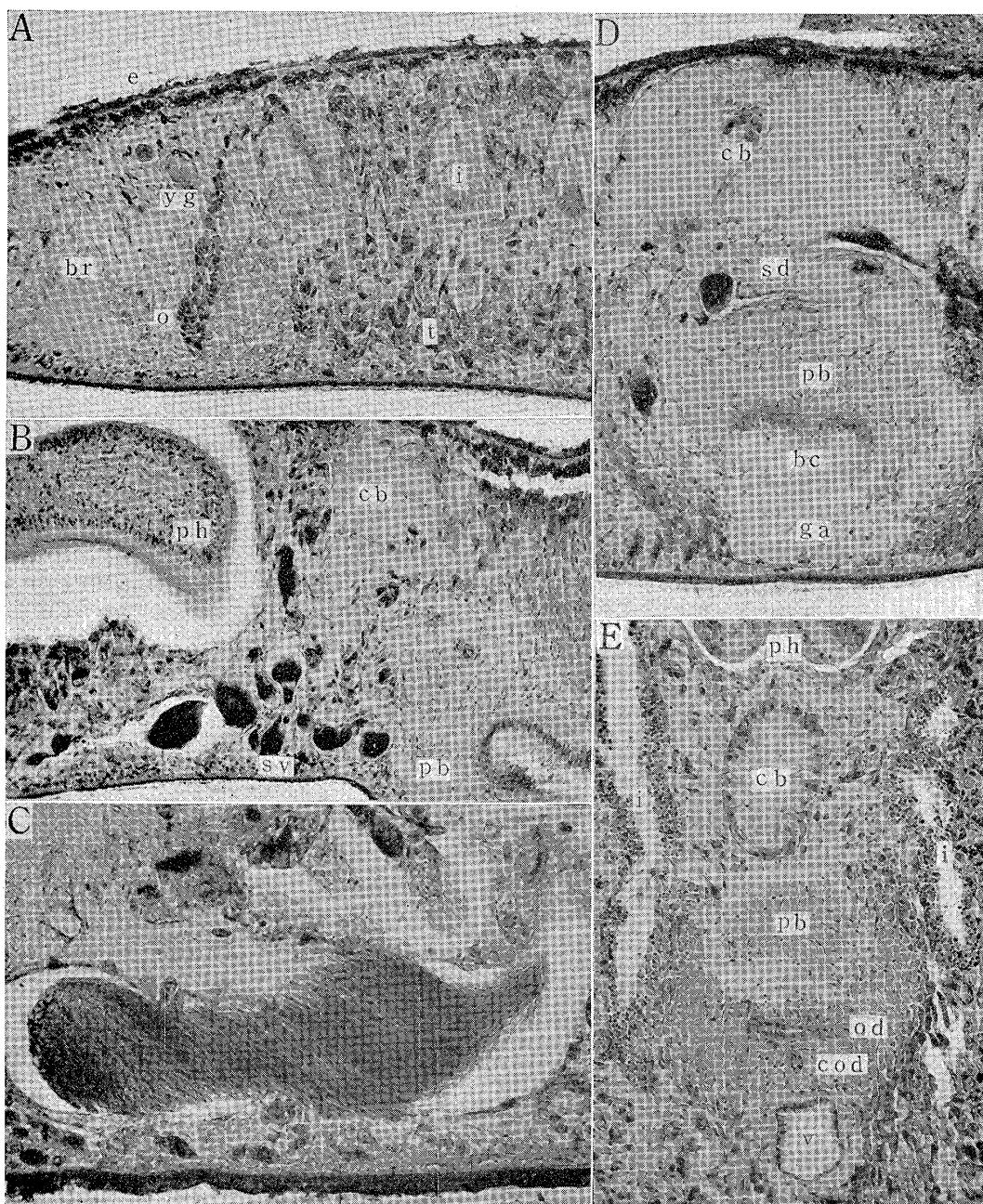


Fig. 3. Reproductive system. All from Nayoro City. **A**: sagittal section of the prepharyngeal region, showing the situations of ovary, yolk glands, testes and brain (No. 291 c). **B**: sagittal section of the pharyngeal region, showing the spermiducal vesicles (No. 291 a). **C**: enlarged photograph of the spermiducal vesicle. Notice the mass of spermatozoa (No. 291 k). **D**: cross section through the penis bulb, at level of entry of the sperm ducts (No. 291 m). **E**: horizontal section of the copulatory apparatus (No. 291 q). **bc**: bulbar cavity, **br**: brain, **cb**: copulatory bursa, **cod**: common ovovitelline duct, **e**: eye, **ga**: genital antrum, **i**: intestine, **o**: ovary, **od**: ovoovitelline duct, **pb**: penis bulb, **ph**: pharynx, **sd**: sperm duct, **sv**: spermiducal vesicle, **t**: testis, **v**: vagina, **yg**: yolk gland.

end of the body. Transverse and sagittal sections show that the testes are situated ventrally; only occasionally some of them rise towards the dorsal side. Behind the genital pore, they are also found between the two intestinal trunks.

The two, fairly large ovaries are in the normal position below the second intestinal branch (Fig. 3A). The two oovitelline ducts (or oviducts) run posteriorly above the ventral nerve cords. The numerous yolk glands (or vitellaria) occur throughout the body between the intestinal diverticula.

Sagittal views of the copulatory apparatus of two different worms, the Nayoro and the Wakkai specimens, are shown in Figure 4 (A and B); Figure 5 (A, B, C and D) shows the microphotographs of the copulatory apparatus of four different worms from two different localities.

The genital pore, leads to the genital antrum, an undivided cavity (Fig. 4A). It is narrow at the pore and expands anteriorly. In many sections of the Nayoro specimens it was frequently observed that a wide cavity of the genital antrum is surrounded by the dorso-posterior wall of the antrum and the upper side of the penis (Fig. 4A; Fig. 5 A, B and C). This cavity of the antrum leads dorsally into the canal of the copulatory bursa or the vagina. Just before this junction the cavity receives into its dorsal wall a common oovitelline duct, formed by the union of two oovitelline ducts which run to the lateral sides of the male apparatus (Fig. 3E). Terminal portions of the oovitelline ducts and the common oovitelline duct receive numerous eosinophilic glands.

In several slides, particularly in those of the Wakkai specimens, however, there appears to be a differentiation of the genital antrum into the relatively narrow male antrum containing the penis and the narrow common antrum (Fig. 4B; Fig. 5D). These differences in appearance of the genital antrum are, of course, chiefly due to the degree of the muscular contraction in which the worms were killed. Another reason may lie in the fact that the penis of the Wakkai specimens is often slightly shorter than that of the Nayoro specimens.

The wall of the genital antrum is lined with a very tall, highly glandular epithelium; the glandular epithelium of the antrum in the ventral side is flatter than that of the dorsal. The muscle fibres which lie below the epithelium consist of two layers, one circular and the other longitudinal. The narrow posterior part of the genital antrum receives the outlets of numerous cement glands, the secretion of which becomes red when stained with eosin.

The penis has a weakly muscular bulb embedded in the parenchyma and a well-developed papilla projecting into the genital antrum. In worms that were fixed in a well extended condition, the bulb appears semispherical and the papilla has a symmetric conical shape. Under its cubical covering epithelium the papilla is provided with a circular and a longitudinal layers of the muscle fibres.

The penis bulb contains a single bulbar cavity from which a wide ejaculatory duct continues to the tip of the papilla, both lined by a tall epithelium. The shape of the penis lumen (of both the bulb and the papilla) is changeable; Figure 5 (A and C) shows the typical shape; Figure 5 (D) shows the shape when the bulb is strongly contracted. The bulb is penetrated by many gland ducts which open into the penis lumen. These ducts contain a granular, faintly eosinophilic secretion.

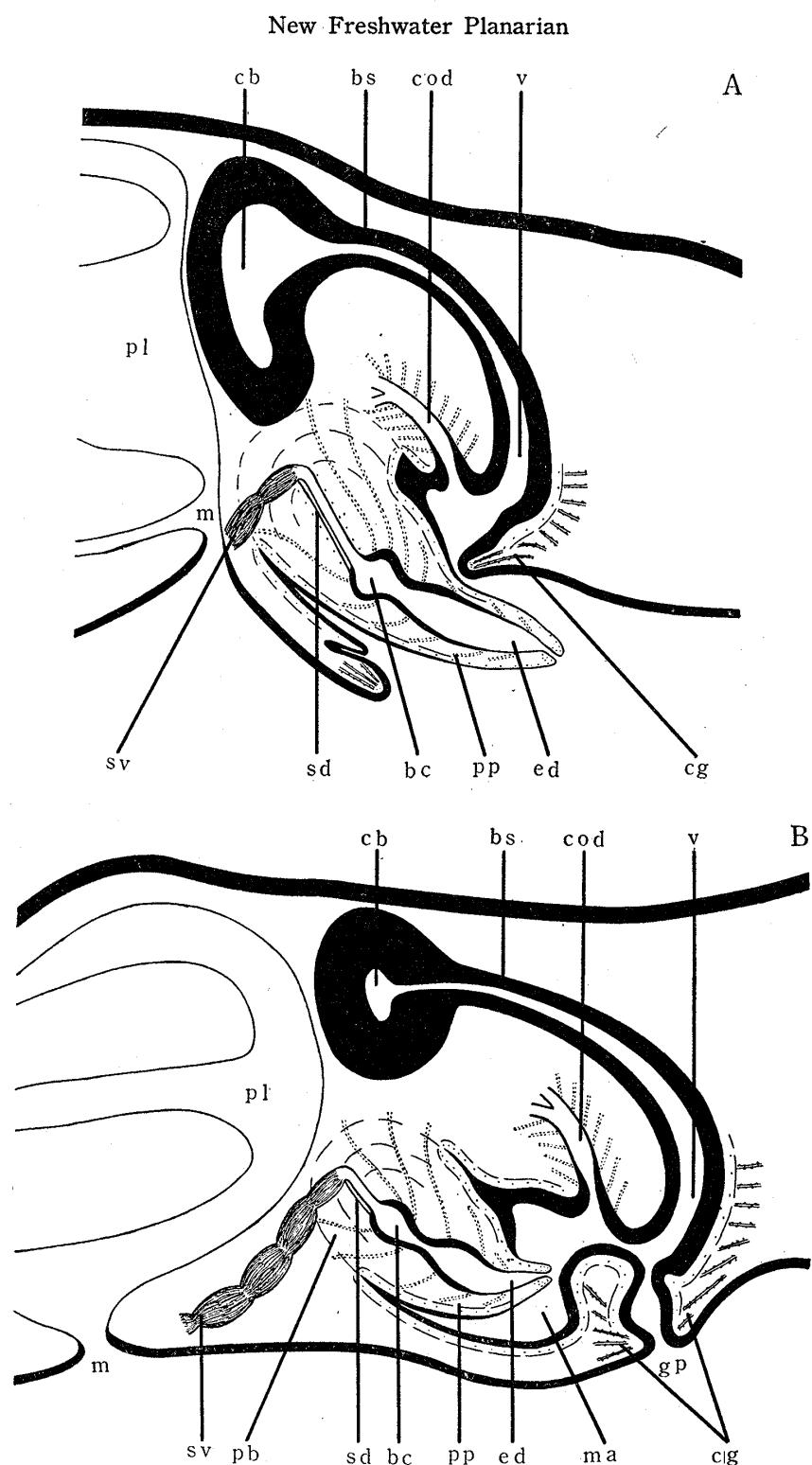


Fig. 4. Diagrams showing the sagittal view of the copulatory apparatus. A: Nayoro specimen. B: Wakkai specimen. bc: bulbar cavity, bs: bursa stalk, cb: copulatory bursa, cg: cement gland, cod: common ovoiduct, ed: ejaculatory duct, gp: genital pore, m: mouth, ma: male antrum, pb: penis bulb, pl: pharynx lumen, pp: penis papilla, sd: sperm duct, sv: spermiducal vesicle, v: vagina.

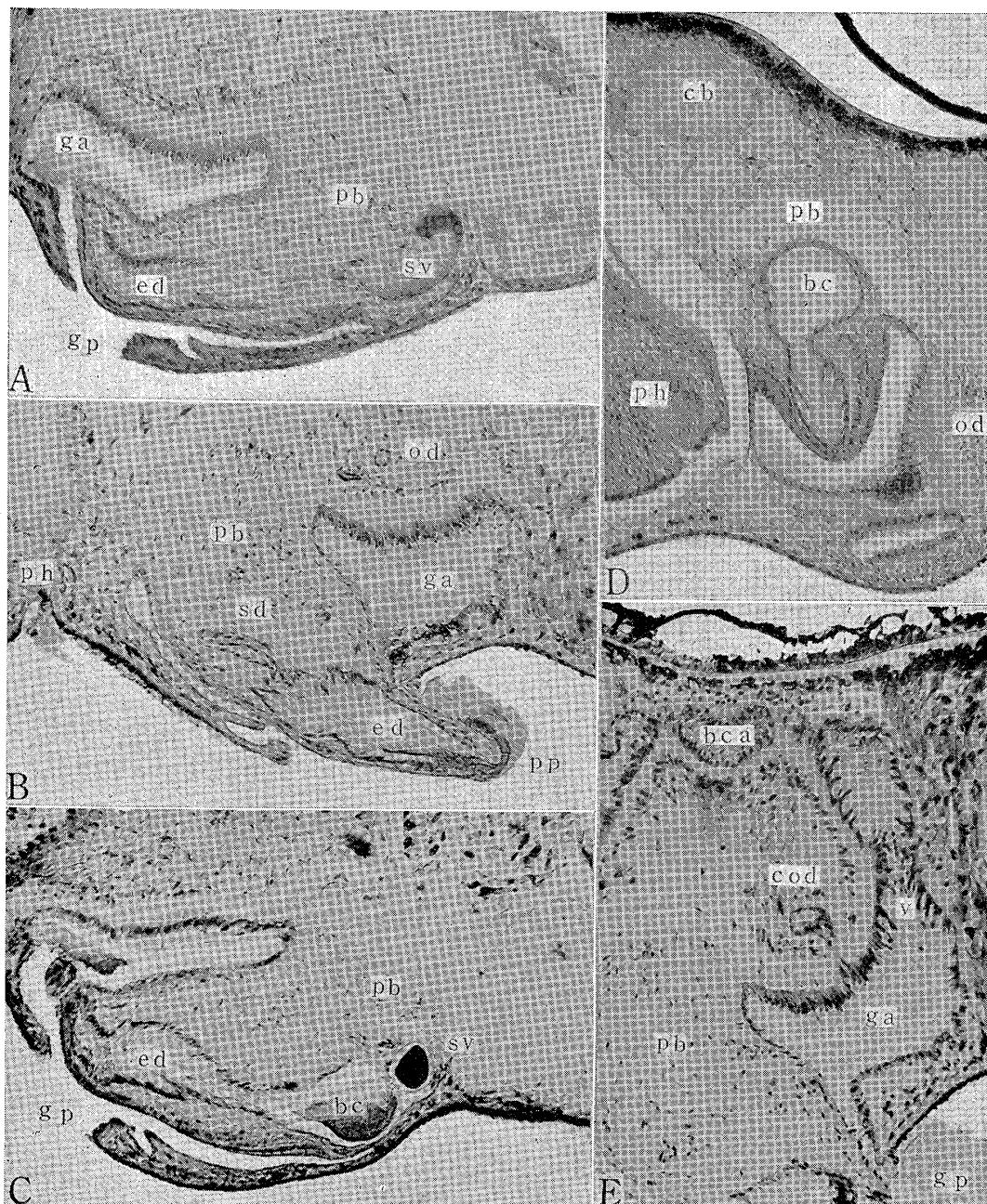


Fig. 5. Sagittal sections of the copulatory apparatus. **A**: penis (Nayoro specimen, No. 291 d). **B**: penis (Nayoro specimen, No. 291 h). **C**: penis (Nayoro specimen, No. 291 k). **D**: penis (Wakkanai specimen, No. 215 g). **E**: vagina and common oovitelline duct (Nayoro specimen, No. 291 h). *bc*: bulbar cavity, *bca*: bursal canal, *cb*: copulatory bursa, *cod*: common oovitelline duct, *ed*: ejaculatory duct, *ga*: genital antrum, *gp*: genital pore, *od*: oovitelline duct, *pb*: penis bulb, *ph*: pharynx, *pp*: penis papilla,, *sv*: spermiducal vesicle, *v*: vagina.

The two sperm ducts form a large tube or sac, the spermiducal vesicle, on each side of the mouth and the male apparatus, respectively. Then they bend,

back and enter the bulbar cavity from the antero-lateral sides of the penis bulb separately. In our material, in almost all worms which were collected in both the localities, Nayoro City and Wakkai City, it was observed that the spermiducal vesicles were densely filled with spermatozoa (Fig. 3 (B, C and D). As shown in Figure 2, these ducts can easily be recognized from the ventral side in living worms as well as in the stained whole mount.

The copulatory bursa, which is situated in the usual dorsal position, is a rather small sac with rounded outline. The cavity of this organ is lined by a very tall and thick glandular epithelium. The bursa stalk, a rather short but thick tube in appearance, springs from the posterior side of the copulatory bursa. It runs posteriorly above the penis, then curves ventrally and opens into the roof of the genital antrum. The bursal canal is also lined by a thick epithelium with villus-like projections. The posterior terminal part of the bursal canal becomes somewhat wider and forms the vagina (Fig. 4E). There is, however, no histological differentiation into anterior and posterior sections of the bursa stalk. *Taxonomic Remarks and Differential Diagnosis.* Concerning the taxonomy and distribution of the known species of the genus *Phagocata* and several uncertain species that may belong to the same genus reported from the North Pacific areas (the north-eastern part of the Far East, the Japanese Islands and Alaska) were minutely discussed in our previous paper (cf. Ichikawa and Kawakatsu, 1962). In these *Phagocata* species, the two unpigmented species, *Phagocata albata* Ichikawa et Kawakatsu (1962) and Alaskan *Phagocata nivea* Kenk (1953), have a striking resemblance to our present form. Externally, it may be said that in life our present form is hardly distinguishable from *Phagocata kawakatsui* Okugawa (1956) but it differs in the details of the copulatory apparatus.

*Phagocata iwamai* differs from the closely related *Phagocata kawakatsui* or other species of *Phagocata* in the cone-shaped symmetric penis papilla with its wide ejaculatory duct, a less muscular penis bulb, a very tall epithelium of the genital antrum, a thick and rather short bursa stalk and the absence of the thick radial musculature on the vagina.

*Holotype.* One whole mount of the better of the Nayoro specimens (Specimen No. 299 a) deposited in Professor Ichikawa's room of the Zoological Institute, Faculty of Science, Hokkaido University; 25 other whole mounts (No. 299 b-z) and 17 sets of sections (No. 291 a-q). 20 sets of sections of the Wakkai specimens (No. 215 a-t) too, deposited in the same room.

*Locality.* Collected by M. Kawakatsu and T. Yamada in a spring-fed creek, Nayoro City, in North Hokkaido; and by M. Kawakatsu in a brook, near the Hokumon Shrine, Wakkai City, in North Hokkaido.

*Distribution and Ecology.* The habitats of *Phagocata iwamai* in Hokkaido are as following.

1. Creek in the school ground of Hokkaido University, Sapporo City (altitude, 40 m). Slowly running, not very clear water; bottom mud, here and there rich vegetation. Aug. 13, 1956: 2 immature worms (15.2°C, pH 6.6). The four species of freshwater planarians, *Dugesia gonocephala* (Dugès), *Polycelis sapporo* (Ijima et Kaburaki), *Dendrocoelopsis ezensis* Ichikawa et Okugawa and *Dendrocoelopsis lacteus* Ichikawa et Okugawa, occurred in this habitat.

*Phagocata iwamai* was also found at Kotoni (coll. S. Ishii) and Yokoshibetsu River (Kikuchi, 1956), near Sapporo City.

2. Creek in Nayoro City (altitude, 100 m). Slowly running water fed by a large spring; bottom muddy or sandy, with few stones, here and there rich vegetation. May 5, 1961: very numerous, mature and immature, worms (6.0°C, pH 5.6). *Pol. sapporo*, *Den. ezensis* and *Den. lacteus* occurred.

According to Mr. T. Yamada, seasonal change of the water temperature in this habitat ranged from 2 to 12.5°C.

3. Brook in Wakkanai City (altitude, 10 m). Slowly running water; bottom sands and mud. Aug. 29, 1957: many, mature and immature worms (14.8°C, pH 6.4). *D. gonocephala*, *Den. ezensis* and *Den. lacteus* also occurred.

*Note on Culture.* In the laboratory cultures (room temperature, 10–20°C; refrigerator, 5–10°C), their sexual organs were usually developed from winter to early spring. Copulation was frequently observed in the breeding season. The amount of eggs laid was greatest in June.

The cocoon is elliptical in shape and is coated with translucent adhesive secretion of the cement glands (Fig. 1F). This coating broke after a few days. They are reddish in color but soon darken to chocolate-brown and harden. The size of cocoon varies considerably; 55 cocoons (including Yamada's data) we measured, attained  $0.5 \times 0.5$  mm (1),  $0.7 \times 0.6$  mm (3),  $0.8 \times 0.7$  mm (12),  $1.0 \times 0.9$  mm (16),  $1.2 \times 1.0$  mm (17),  $1.5 \times 1.2$  mm (4), and  $1.7 \times 1.4$  mm (2) (long axis  $\times$  short axis). From the data furnished by Mr. T. Yamada, their hatching was usually observed within 30 days after the depositing. In general, 2 to 6 larvae emerge from 1 cocoon.

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